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an object centrally, the attention may be turned to an object on the side, with the result that while there is no change in the accommodation of the eye, there is in the attention, and in the objects perceived. So Helmholtz, and also Pilzecker in his train.

Heinrich points out that Helmholtz's statements are only the results of subjective perception; there is need of an objective investigation, as "self-analysis" may not reveal the state or change of the eye during the experiment. He therefore observes the pupils and lens with the help of an ophthalmometer. He determined carefully the size of the pupil (1) in central fixation, (2) in indirect vision, and (3) in reckoning. From the various tables it is evident that when the subject turns his attention to the object seen on the side, the pupil enlarges. For example, Table III gives the size of pupil centrally fixated at 3.0091 mm.; with object seen at angle of 50° as 4.9094 mm.; and at 70° as 3.9514 mm.; and during mathematical calculation at 6.0565 mm. The size of the pupil varies continually. If the attention be claimed by non-optical impressions, the pupil loses its condition of accommodation. Helmholtz is wrong therefore; the attention, at least in this case, is accompanied by the accommodation of the eye.

Dr. Haab (*Neurologisches Centralblatt*, 1886, 1 Mai, and in *Correspondenzblatt f. Schweizer Aerzte*, 1886, 15 März) reports a case of pupil-reflex not noticed by Heinrich. Again it is a case of indirect vision and attention; but here it is not an enlargement, but a contraction of the pupil! He regards it as probably of cortical origin and cites psychiatric cases to illustrate his argument. The discrepancy between the statements of Haab and Heinrich is probably due to the objects fixated (lamp, dark wall, etc.) and the respective positions occupied by the subjects examined. The different results, however, demand more experimentation. In either case, however, Helmholtz's view is amply refuted.

ARTHUR ALLIN.

Das Verhältniss von Accommodation und Konvergenz zur Tiefenlokalisation. Von Dr. FRANZ HILLEBRAND. *Zeitschrift für Psychologie*, VII, 1894, 97-151.

On the Relation of Accommodation and Convergence to Our Sense of Depth. By E. T. DIXON, *Mind*, N. S. IV, 1895, 195-212.

In the experimental study of the relation of accommodation to space perception, Hillebrand's sole predecessor is Wundt, who published on the subject more than thirty years ago. Wundt's general conclusion was that, all other means of perception being excluded, differences of distance could be perceived by differences in an "accommodation feeling;" Hillebrand's is that such a feeling does not exist. This conclusion rests on two series of experiments. In one a fixation line was moved slowly to or from the eye of the observer, and he was required to say whether it was approaching or receding; in the other, the observer's eye being accommodated for a fixation line at rest in the field, the line was suddenly removed and another at the same or a different distance substituted for it. For the detail of the apparatus and for the many necessary precautions to be observed, the original should be consulted. Suffice it to say here that with possibly one small exception to be noticed below, the conditions leave nothing to be desired. The first series of experiments showed an almost uniform inability on the part of the observers to judge—much less to "sense"—the direction in which the line was traveling. In the second series it

was in the main possible to tell the direction of the change, provided its amount was sufficient. This result is an apparent contradiction to that of the first series, but in discussing it Hillebrand makes it seem probable that the success rests ultimately on the blurring of the retinal image and the voluntary efforts of accommodation required to get it clear—quite a different thing from sensations of the muscular effort of accommodation.

The most interesting, though perhaps not the most permanently valuable part of Dr. Hillebrand's paper, is his effort to use these results as a demonstration of the absence of muscular sensations of convergence as well as of accommodation. His argument runs as follows: Between accommodation and convergence there is an habitual association, so strong that under normal circumstances change in one introduces change in the other, even when but one eye is open. Now if it is true that changes of distance cannot be perceived by accommodation and convergence combined, they cannot be perceived by convergence alone. (The ordinary binocular experiments, which seem to show the importance of convergence, are inconclusive, because they do not exclude the possibility of perception by means of double images.) If this argument is allowed and Hillebrand's experiments confirmed, all "eye-muscle" theories of space fall together.

It is to this point that Dixon's criticism is directed. He has carefully repeated the experiments and finds results substantially the same as Hillebrand's; such differences of results as are enumerated seem to the reviewer rather apparent than real. In the interpretation of the results, however, and especially with regard to the inferences against convergence-sensations, he takes a very different ground. That Hillebrand's first series showed only negative results may prove nothing more than that the changes were too gradual to be perceived. It certainly ought not to be stretched to prove that there are no convergence-sensations, for the connection between accommodation and convergence is quite loose. Indeed it may even be that the errors were due directly to improper convergence. A special series of experiments undertaken to measure the possible dissociation of the two showed the bond between them quite elastic. For incidental observations of interest with reference to judgments made with presbyopic or atropined eyes the paper itself should be consulted.

Taken together, the work of these two experimenters creates a good deal of doubt as to the existence of "muscular sensations" accompanying accommodation—except perhaps when it becomes of unusual amount,—and it seems to be incumbent on those who believe in them to bring forward new evidence.

A single point as to apparatus, which might have a certain influence, seems to have been overlooked by both experimenters. In both cases the observer looked through a short tube, the further end of which limited his field of vision. The edge of this opening was of course seen in diffusion circles, which changed as accommodation changed, and may have furnished still another retinal means of inferring the state of accommodation and with it the distance of the line accommodated for.

E. C. S.